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Temperature, pH, Electrical Conductivity, Total Dissolved Solids and Chemical Oxygen Demand of Groundwater in Boji-BojiAgbor/Owa Area and Immediate Suburbs

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ABSTRACT

Temperature, pH, conductivity, total dissolved solids and chemical oxygen demand in ground water of Agbor/Owa town and immediate suburbs were studied. Groundwater is the predominant source of water by inhabitants of these communities without any treatment. However, the quality of this water source is not immediately known, therefore, there is the question of its safety. Temperature readings were taken on site using mercury in glass thermometer, pH and conductance readings of the samples were quickly determined by Corning pH meter model 430 and DDS 307 conductivity meter, TDS and COD by APHA standard methods, respectively. Analyses reveal that temperature, pH, conductivity and TDS range of 27.0-28.1°C, pH was 6.10-6.97, conductivity 8.25-14.46 μS cm^{-1}, TDS 4.13-7.22 mg L^{-1} and COD 46.80-93.60 mg L^{-} .^{1} Correlational matrix showed temperature correlated very positively with EC and TDS and to a lesser extent with COD. Other positive correlates were between: EC with temperature and TDS; TDS also showed very strong correlation with temperature and EC. The mean values recorded for all studied parameters were 27.7°C, 6.81, 11.08 μS cm^{-1}, 5.53 and 62.72 mg L^{-1} for temperature, pH, EC, TDS and COD, respectively. These suggest that the groundwater is of rather good quality with values quite below and within the guideline values of WHO, USEPA and Nigerian water safety standards.

Key words: Ground water, Boji-BojiAgbor/Owa, temperature, pH, conductivity, total dissolved solids, chemical oxygen demand

INTRODUCTION

Water is very essential for life. Water is an invaluable resource to man and living things, essential for the sustenance of life Al Nahyan (2012) on earth as exemplified by its diversified uses (drinking, cooking, washing, irrigation, farming etc.) (Rim-Rukeh *et al.*, 2007). The quality of drinking water is a powerful environmental determinant of health (WHO, 2010). Adequate supply of safe drinking water therefore is universally recognized as a basic human need and one of the most essential factors of civilization. Millions of people in developing countries do not have access to adequate and safe water supply. Increasing population and urbanization make it difficult for governments around the world to meet the increasing demand for portable drinking water. In a recent survey by Majuru *et al.* (2011), it is estimated that 65 million Nigerians had no access to safe drinking water.

Many human communities around the world are increasingly turning to groundwater for their water needs. Groundwater is water that exists underground (Groundwater Foundation, 2012). It represents all the water present in the soils' voids and fissures within geological formations which come from natural precipitation either directly by infiltration or indirectly from rivers (Saeed and Khan, 2014). In Agbor/Owa area in Delta State, Nigeria, groundwater has steadily replaced the moribund public water supply and the formally commonplace hand dug wells which served essentially as reservoirs during the rainy and dry seasons. Without safe water near dwellings, the health and livelihood of families can be severely affected (United Nations, 2000; MacDonald and Calow, 2009). However, the quality is under intense stress from increasing demand and withdrawal, significant changes in land use pattern, climate change and pollution arising from geological and geochemistry of the environment (Edmunds and Smedley, 1996).

Although, groundwater in its natural state is relatively free of contaminants and traditionally regarded as having good natural quality (MacDonald and Calow, 2009). For most of the geological environments this is true but this does not mean that natural groundwater quality is always good. The natural quality can vary from one rock type to another and also within aquifers along groundwater flow paths (MacDonald and Calow, 2009). Concentrations of target substances in the groundwater increase or decrease along the flow path from the upstream to the downstream wells (Leschik *et al.*, 2009), human activities may consequently pollute this water source overtime and make it unsafe for use without prior treatment. More so, several research findings (UNICEF, 2008; WHO, 2010) have revealed a definite correlation between human socio-economic activities and industrialization to pollution patterns/trends of groundwater. Furthermore, it is expected therefore, that as we move from the hub of the city to the suburbs (a shift from one socio-economic stratification to another), it would be expected that the groundwater quality should deviate even slightly. This is further given credence by the UNDESA (2001) in saying that the quality of any body of surface or ground water is a function of either or both natural and human influences. The continued consumption of untreated and possibly contaminated groundwater should be expected to pose short or long term (or even both) health implications to the people.

Therefore, the evaluation of groundwater quantity and quality is essential for the development of civilization and to establish database for future water resources strategic planning and development (Al-Harbi *et al.*, 2006). Studies on groundwater have been carried out in different parts of Nigeria; however, no comprehensive study has been conducted on the groundwater quality in Agbor/Owa (Boji-Boji) area. In this study, we report the temperature, pH, electrical conductivity and total dissolved solids (physical parameters of water quality) analyses of groundwater in this study area.

MATERIALS AND METHODS

Study area: The study area (Agbor/Owa town) located within longitudes 6°-6° 30' E and latitudes 6°-6° 30' N, comprising the city centre of two Local Government Areas (Ika North East and Ika South) was mapped out in to five sub-areas of Agbor Obi, Boji-BojiAgbor, Boji-BojiOwa, Alihame and OwaAlero (Fig. 1 and 2).

The latter two areas (Alihame and OwaAlero) being classified as suburban towns for the purpose of this exercise, on the basis of socio-economic activities and population density; with special reference to the cluster of mechanic (car, lorry, motor bike and electricity generators repairers), iron and steel workers, hair dressers and barbers, quality of residential buildings and offices and sewage disposal systems (including septic tanks) and amounts and types of refuse (solid wastes) generated

Fig. 1: Map of Nigeria showing Delta State (Source: Google map)

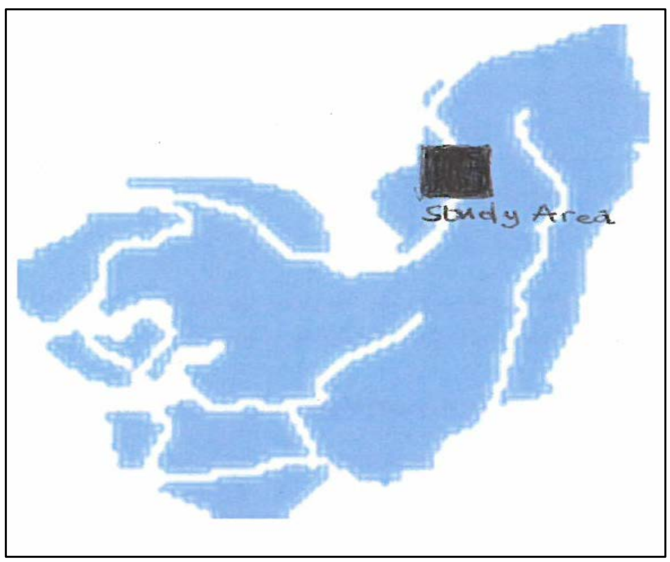

Fig. 2: Map of Delta State showing sample area

and methods of disposal. The geology of the area is mainly of recent tertiary sedimentary sand stone, with the Bini formation as a typical example. This indicates a lee way for easy passage of leachate through to the ground water in the underlying aquifer. The climate of the study area exhibits the characteristics of a sub-equatorial climate with an annual mean air temperature of 28.0°C (Odjugo, 2008). The rainfall pattern is that of double peaks or maximal with mean annual rainfall of 2,255 mm while the mean relative humidity is 81%, sunshine is 5.6 h day^{-1} and the soil type is red-yellow ferralsols (Avwunudiogba, 2000).

Sampling and sample areas: A total of 50 borehole water sources were sampled in all from these areas within the period of the 4th-18th of August, 2013, with an average of about 15 per area for Agbor Obi, Boji-BojiAgbor and Owa areas and five for OwaAlero and Alihame communities on the basis of fewer wells per unit area.

Samples were collected in clean new 300 mL sterile bottles with corks (Burubai *et al*., 2007), from taps at the wells. Borehole water samples were randomly spaced and collected in these bottles filled to the brim, put in dark ice box and immediately taken to the laboratory situated not more than 5 min drive from the sample areas for analyses.

At the laboratory, the samples were carefully transferred in to a clean and larger container of 4 L in capacity previously sterilized and a composite sample was thus formed per sample area. Samples were collected on different days and in the mornings in the month of August, 2013.

Temperature readings were taken on site using mercury in glass thermometer. Immediately at the laboratory, pH and conductance readings of the samples were quickly determined using Corning pH meter model 430 and DDS 307 conductivity meter, respectively at an average temperature of 28.5°C. The TDS and COD by APHA standard methods (APHA, 1998, 2005), respectively. All determinations were done in triplicates and the mean values recorded.

RESULTS AND DISCUSSION

Groundwater temperature values in the study area ranged from 27.0-28.1°C, with an average value of 27.7°C. These suggest that the groundwater temperature is generally ambient and good for consumers who prefer cool to warm water and for the specific reason of water quality; since, high temperature negatively impact water quality by enhancing the growth of micro-organisms which may increase taste, odour, colour and corrosion problems (UNICEF, 2008). Therefore, it is important that groundwater temperature is not too high in order not to have microbial proliferation. Temperature affects biological, chemical and physical activities in the water (Yilmaz and Koc, 2014). Besides, increase in temperature of water decreases solubility of gases such as O_2, CO_2, N_2 and CH_4 (Yilmaz and Koc, 2014).

pH values of water samples from each of the sample areas are displayed. A pH range of 6.09-7.05 was obtained in all; with both Boji-BojiAgbor and Owa recording values around 7.0. Agbor Obi had the most acidic pH of 6.10 falling slightly below the guideline limit of 6.5-8.5, thus indicating corrosiveness. However an average pH of 6.81 is recorded for the entire study area; this is consistent with results obtained by Ahaneku and Adeoye (2014). The World Health Organization (WHO, 2010) recommends a pH value of 6.5 or higher for drinking water to prevent corrosion. Although, a pH above 8.0 would be disadvantageous in the treatment and disinfection of drinking water with chlorine (UNICEF, 2008). However, pH values between 6.5 and 8.5 usually indicate good water quality and this range is typical of most drainage basins of the world (UNEP/GEMS, 2007).

Conductivity values of the ground water samples are presented in Table 1. This is a measure of the dissolved ionic component in water and hence electrical characteristic. Electrical conductivity gives an indication of the amount of total dissolved substitution in water (Yilmaz and Koc, 2014). Values recorded ranged from 8.23-14.46, meanwhile, the least conductivity values were observed for OwaAlero and Alihame (the suburbs) with 8.24 and 8.25, respectively. Both Boji-Boji areas (Agbor and Owa) had averages of 12.22 and 12.23, respectively. Agbor Obi area meanwhile, pooled the highest probably due to difference in altitude being far higher altitude-wise and presumably has the lowest water table, therefore probably had a more net leaching effect by comparison. Conductivity of the groundwater for the entire study area stands at an average of 11.08 $\mu S\ cm^{-1}$.

This gives a picture of very little solute dissolution generally in the groundwater, rapid ion-exchange between the soil and water, or basically a poor and rather insoluble geologic rock and mineral types.

From values of TDS also in Table 1, all the sample sites reported values very far below the WHO recommended guideline value of 1000 mg L^{-1}. Low TDS is said to be a characteristic of hills and upload areas that represent areas of recharge according to Olobaniyi *et al*. (2007) this is an apt description of the study area topographically. Water containing TDS less than 1000 mg L^{-1} could be considered to be "Fresh water" and good enough both for drinking and irrigational purposes, as this would not affect the osmotic pressure of soil solution according to Freeze and Cherry (1979) and Shahidullah *et al*. (2000).

COD values ranged from 46.80-93.60 mg L^{-1}, the highest recorded for Boji-BojiOwa. OwaAlero was next with 67.60 mg L^{-1} COD while Boji-BojiAgbor recorded the least COD value of 46.80 mg L^{-1}. In general, the COD value for the area under study is at an average of 62.72 mg L^{-1}. COD values in this study suggest a rather low organic content in the soil and groundwater of this study area. As organic matter is the major source of carbonaceous and nitrogenous substances in soil and water bodies; arising from the use of fertilizers, animal and human waste and decaying plant matter all of which gets to the aquifer through leaching.

Correlational matrix study of the parameters (Table 2) shows a positive correlation between some of the parameters, temperature correlated very positively with EC and TDS and to a lesser extent COD. Other positive correlations are between: EC with temperature and TDS; TDS also showed very strong correlation with temperature and EC. The amount by which EC rises depends on increase in temperature (Yilmaz and Koc, 2014).

Water temperature according (Lenntech, 2014) affects the EC so that its value increases from 2 upto 3% per 1°C. However, COD showed weak though positive correlation, with temperature and pH. By interpretation, the temperature of the groundwater impacts significantly on the EC, TDS and COD and vice versa. Correlation coefficient is a common tool used to assess

Table 1: Temperature, pH, conductivity, total dissolved solids and chemical oxygen demand of the water samples obtained from each of the five sample areas

Place (Sample area)	Temperature (°C)	pH	Conductivity (μS cm^{-1})	Total dissolved solids (mg L^{-1})	COD (mg L^{-1})
Agbor Obi	28.1	6.10	14.44	9.92	51.20
Boji-BojiAgbor	28.0	7.01	12.22	8.28	46.80
Boji-BojiOwa	28.1	7.00	12.23	8.30	93.60
OwaAlero	27.5	6.97	8.24	5.16	67.50
Alihame	27.0	6.97	8.25	5.20	54.40
Mean	27.7	6.81	11.08	7.37	62.70
SD	0.5	0.40	2.74	2.11	18.92

Table 2: Correlational matrix of physical parameters studied

Parameters	Temperature	pH	Conductivity	TDS	COD
Temperature	1	-0.381	0.888*	0.890*	0.215
pH	-0.381	1	-0.654	-0.642	0.342
Conductivity	0.888*	-0.654	1	1.000**	-0.055
TDS	0.890*	-0.642	1.000**	1	-0.048
COD	0.215	0.342	-0.055	-0.048	1

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed) the relationship between two variables and how well one predicts the other (Bahar and Reza, 2010). Thus, high correlations show that the parameters are derived from the same source (Edet *et al.*, 2011).

CONCLUSION

Temperature, pH, conductivity, electrical conductivity, total dissolved solids and chemical oxygen demand of groundwater in Agbor/Owa (Boji-Boji) area were studied. Temperature values are consistent with tropical belt, it can be considered as being ambient relative to the geographical region and not too bad in terms of supporting microbial growth. Average pH is slightly acidic and indicates corrosion problems, especially in Agbor Obi area. Electrical conductivity and total dissolved solids values are very low; these give a measure of the ionic load and contaminants in the water. Hence, from the EC and TDS values, the groundwater of this study area can be said to have low salt concentration and good for drinking and crop production. Furthermore, the pH and EC values infer that the water is clearly not saline and suggest its possible likelihood for irrigation agriculture. Although, other factor like Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) of the groundwater will have to be studied. Meanwhile, findings suggest that the groundwater in this aquifer is fresh. Chemical oxygen demand values, further give credence to the freshness of the water, implying yet again very minimal organic presence, translating by inference, to good taste, odour and esthetic quality. All parameters clearly fell below WHO international best standards for water quality.

Therefore, from results of this study, the groundwater in the study area can be regarded as being of good quality for drinking and agriculture purposes with reference to the parameters under consideration, although with little pH treatment especially in Agbor Obi area. However, further studies with reference to the chemical and microbial analyses will have to be done to have a broader picture of this water quality.

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